c. Coefficient of oblique air pressure (Lanchester). The value of this depends on the aspect ratio of the surface. From Duchemin's rule for square surfaces it is 2; Eiffel gives a value of 3; Lanchester gives hypothetical values between 2 and 3.

ξ. Ratio of skin friction on a double surface to the normal resistance of the plane of the same single-surface area.

β. Angle of incidence (Radians).

V. Relative velocity of air to surface.

l. Length of surface in the direction of flow.

A.

I.—*Frictional Resistance deduced from the Head, or Total Resistance of Dirigible Balloons.*

The resistance of a well-shaped dirigible is, like that of a ship, almost entirely due to skin friction. The aërodynamic resistance of cars, rigging, &c., is almost negligible in ratio to the skin friction, certainly not exceeding 30 per cent. thereof.

If, then, the area of the skin is A_1, and that of the maximum cross-section is A_2, and k is the ratio of the skin friction to the aërodynamic resistance of a normal surface with the same shape as the mid-section, this definition of k may be written:—

$$\frac{fA_1}{C\rho A_2} = k \quad \ldots \ldots \ldots \quad (1)$$

The coefficient k has been measured for several dirigibles, and forms the basis of this computation.

Name	Length	Diameter	A_1	A_2	k	f
Renard and Krebs	50·42 m.	8·4 m.	1330 sq.m.	55·4	0·4	0·000033
			(Espitallier, Genie Civil, 1902)			
Zeppelin III. ..	128	11·66	48000	100	0·45	0·000025
			(Moedebeck's Pocket Book)			
Lebaudy	58	10·3	2000	80	0·31	0·000030
				(Ditto.)		
Spherical Conoid.	6D	D	$6\pi D^2$	$\frac{1}{4}\pi D^2$	0·16	0·000014
			(Molesworth's Pocket Book[1])			
	Total ...					0·000102
	Mean value ...					0·000025
	Deduct 30 per cent. for other resistance ...					0·000008
						0·00001

The value 0·000025, seeing that it certainly includes some aërodynamic resistance due to imperfect form of envelope and the resistance of car and rigging, should be regarded as the absolute maximum.

II.—*Frictional Resistance deduced from the Efficiency of a Plane Aërofoil.*

According to Turnbull (*Physical Review*, March, 1907), the lift-to-drift ratio is a maximum for planes of an aspect ratio of two, when the angle of incidence is $3\frac{1}{2}$ degrees, and it has then a value of 5·1 ($3\frac{1}{2}$ degrees $= 0·06$ radian).

Employing Lanchester's notation, this ratio (also called by Turnbull the "efficiency")

$$= \frac{Cc\rho AV^2\beta}{\xi C\rho AV^2 + Cc\rho AV^2\beta^2}$$

$$= \frac{c\beta}{\xi + c\beta^2}$$

c, according to Lanchester (compare Dines, Eiffel, and Rateau), is about 2·5, so that $\xi = 0·020$ for the double surface and $f = \xi C\rho = 0·000032$ for the double surface, or for the single surface 0·000015.

III.—*Frictional Resistance in Air deduced by Comparison with that of Water.*

The investigations of Froude have led to a fairly accurate knowledge of the frictional resistance of water, and it has been thought by many that a simple ratio exists between this and that of air in similar circumstances.

Froude's coefficients are between 0·003 and 0·005, the total resistance varying with a power of the velocity from 1·83 to 2·0 when there is considerable turbulence. It is probable that the lower density of air renders it more easily subject to turbulent conditions, so that there can be little doubt as to the approximate truth of the velocity squared hypothesis.

(a) Assuming that the friction is purely dependent on the density, since the density of water is about 800 times that of air, f may be $= 0·004/800 = 0·0000052$.

(b) Assuming that the friction varies as the density, and also as the square root of the kinematic viscosities, an assumption consonant with hydrodynamic theory,

$$f = \text{sq. root of } 12 \times 0·004/800 = 0·000017.$$

IV.—*Zahm's Investigations.*

Prof. Zahm, by experimenting in a wind tunnel on boards, obtained a formula as follows:—

$$f = 0·000008\ l^{-0·07}\ V^{18·5}$$

for smooth surfaces and no vibration, increasing up to $f = 0·00001$ (total resistance varies with V^2) for turbulent conditions and buckram-covered surfaces.

V.—*Lanchester's Investigations.*

Index of velocity variation $= 2$.

Mr. F. W. Lanchester, experimenting with gliding models, and also with an aërodynamic balance (similar to that designed by Ritter von Loessl), obtained various results.

Nature of surface	Method	Coefficient
Mica	Gliding angle of models of variable area	0·000017
,, ...	Gliding angle of model ..	0·000016
Varnished cedar	,, ,, ...	0·000019
Polished ,,	Ballasted aëroplane ...	0·000005
,, ,,	Aërodynamic balance ...	0·000008
Glass paper ...	,, ,, ...	0·000013
		6) 0·000078
	Mean value for moderately smooth surfaces	0·000013

VI.—*Collected Results.*

I. From the resistance of dirigibles ...	0·000017
II. Turnbull's observations	0·000015
III. Hydrodynamic theory and Froude's observations of water	0·000017
IV. Zahm's observations	0·000010
V. Lanchester's observations	0·000013
	5) 0·000072
General mean	0·000014

HERBERT CHATLEY.

[1] This result is apparently after Pole's figures, but the resistance seems to have been under-estimated.

BIOLOGY OF THE EEL-FISHES, ESPECIALLY OF THE CONGER.

DURING the Atlantic and Mediterranean cruises of the Danish research steamer *Thor*, in the winter of 1908–9 and summer of 1910, a very large material has been collected of the larvæ of the eel-fishes (Leptocephali). These belong to at least twelve different forms, and several of them can be referred to their parent species.

The material is specially rich in a few of the forms, and this permits of important conclusions being drawn with regard to the biology of these species. At the same time, it has yielded valuable information regarding the occurrence of the very youngest stages (pre-Leptocephali)—information which has long been desired and sought after; and, lastly, it has aided us in the determination of the *age* of the older Leptocephali, a question which the hitherto available information has been quite unable to settle.

The species of eel which is of the greatest practical interest in Great Britain is the Conger, and of this we have now a very large and complete material. Several hundred specimens have been taken—in all stages, from a length of only 9 mm. up to ca. 160 mm.

The larvæ are not difficult to determine, in part from the number of myomeres, which in ten specimens I have found to vary between 153 and 159, thus quite the same as in the adult Conger; below 35 mm. the most posterior

myomeres cannot be counted with certainty, but the pigmentation is sufficiently characteristic.

In the accompanying table (Fig. 1) I give a graphic summary of the Conger larvæ taken on the two cruises of the *Thor*. Without further explanation, it will be evident from this table that the *youngest stages*, of 1–4 cm. in length, have *only* been taken on the summer cruise, the older intermediate stages, of 5–9 cm., *only* on the winter cruise, whilst the full-grown Leptocephali, of

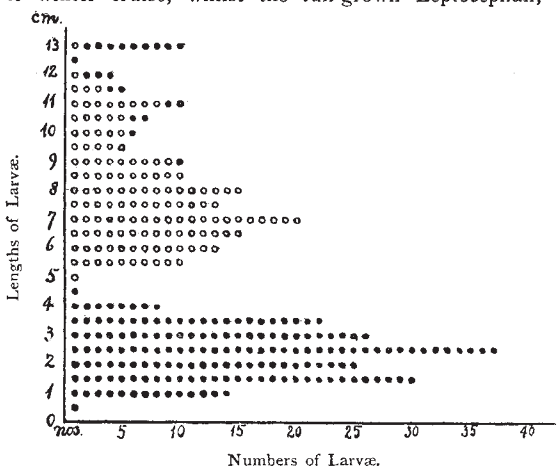

FIG. 1.—Conger larvæ. { • Summer cruise (vi, vii, viii). ○ Winter cruise (xii, i, ii).

ca. 12–13 cm. in length, were taken on both cruises, though mainly in the summer. From the sharp distinction between the youngest specimens taken on the summer cruise and the larger of the winter cruise, we are obliged to conclude that *the spawning of the Conger takes place mainly, if not exclusively, at a certain definite time of year, namely, in spring and summer.* We may further conclude from the material that the larval group of about 7 cm. is about half a year old, and that most of the larvæ of 12–13 cm., some of which are in process of transformation, are about one year old.

All the larvæ recorded in the table were taken in the Mediterranean or in the Atlantic off the Straits of Gibraltar. In earlier years (1905–8), when the *Thor* was working in the northern parts of the Atlantic, west of the British Isles, we also found several Conger larvæ during the period May to September, but these were all older stages, more than 12 and up to 16 cm. in length. The observations made on our last two cruises in the Mediterranean throw a new light on these older discoveries, for we now know that it is extremely easy to take the earliest Conger larvæ in the upper layers, when we know just *where* to find them. We may, in fact, conclude, with a high degree of probability, that the Conger does not spawn in the region examined by the *Thor* to the west of the British Isles, but further south in the Atlantic (Fig. 2, off the Straits of Gibraltar).

A more detailed account of the distribution of the different developmental stages will be given later, but on the accompanying chart I endeavour to summarise the occurrence of the youngest specimens, from 1–4 cm. long, all of which were taken on the summer cruise. It will be seen from this chart that *these earliest developmental stages were mainly taken over very great depths*, outside the 2000-metre line (or near this), but not in the many hauls which were made in the shallower waters. It appears, further, that the largest hauls (including newly hatched larvæ) were made at the deepest places the *Thor* had visited, namely, over depths of more than 3000 metres or about 3000 metres, in the Levant, the Ionian and Tyrrhenian Seas, as also in the deep basin between Sardinia and the Balearic Isles, where we have taken twenty to sixty larvæ in quite short hauls with pelagic apparatus.

These discoveries show that, when the time for reproduction arrives, *the Conger seeks out from the coasts to great depths, where it spawns mainly in the deepest and most central parts of the basins.*

In an earlier paper (1906) I suggested that the youngest larval stages of the eels might be bathypelagic, that is to say, living at great depths below the surface. Perhaps our most important discovery now is that *the earliest pre-leptocephalous stages of the Conger, as well as of the other four to five species the earliest larvae of which I know, really belong to the upper layers.* This can be seen from the hauls at any of our stations where such eel larvæ were taken in quantities. Our practice at each station was to make a series of hauls at varying depths, the length of wire out being 25, 100, 300, 1000, and 2000 metres, and the large quantities of the fry and eggs were always taken in the first, but few, or none at all, in the others. As the depth fished in could not have exceeded 15 metres, we must conclude that the youngest stages and the eggs belong normally to the uppermost layers of water. The older stages (Leptocephali), on the other hand, are also found in greater depths, 100–200 metres below the surface, as I have already shown in my earlier papers, and the life-history of the eel larvæ is thus no exception to the general rule applying to fishes with pelagic eggs, namely, that the earliest stages are passed at or near the surface, and that as development proceeds the larvæ sink down into greater depths.

The renowned Straits of Messina have also become famous in connection with our present subject as the first place where eel larvæ were found. So far as I know, the eel larvæ have never before been discovered in any quantity in the open waters of the Mediterranean, and this is the reason, I believe, why the reputation which the Straits of Messina obtained through the discovery of the Leptocephali there was, to a great extent, undeserved; in any case, the theories which the Italian observers founded on this discovery regarding the bathypelagic or demersal mode of life of the pre-Leptocephali and Leptocephali cannot be maintained. The conditions in the Straits where deep-sea forms and surface forms occur together at the surface are exceptional and abnormal, and the phenomena, biological and physical, we find there are not at all indi-

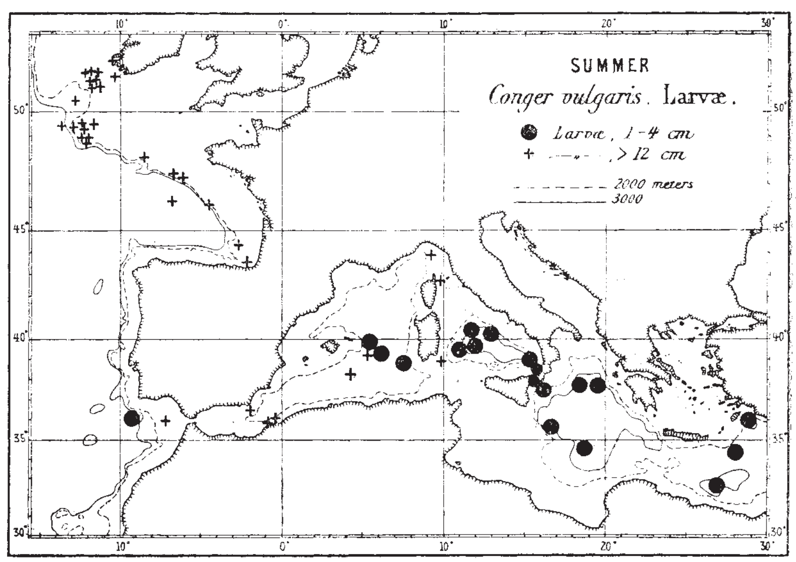

FIG. 2.—Chart of the Mediterranean and Atlantic, showing where the Conger larvæ were taken.

cative of the ordinary course of events. The pre-Leptocephali and the Leptocephali are just as much pelagic animals as, for example, the larvæ of the cod or haddock, and occur in the upper layers not exclusively in the Messina Straits, but everywhere in the various deep basins of the Mediterranean, as well as in the Atlantic.

With regard to the actual spawning of the eels, it is still undecided whether this takes place on the bottom or bathypelagically in great depths of the ocean. In our 1906 cruise we found the Leptocephali of the common eel in great numbers far out in the Atlantic over depths of 4000–5000 metres. Further, the largest quantity of murænoid eggs I have taken were found near the surface in the middle of the Tyrrhenian Sea over about 3500 metres. There is the possibility, therefore, that the eels seek out to these great depths in order to spawn bathypelagically, irrespective of the bottom, but unfortunately it will be very difficult to decide this question one way or the other.

Our present knowledge of the life-cycle of the eels may be summarised as follows.[1]

The eel-fishes spawn in great depths, how far from the surface we do not yet know. The eggs occur pelagically in the surface layers, and there give rise to the pre-leptocephalous stages, which also belong normally to the uppermost layers over great depths. Their whole organisation also shows that the pre-Leptocephali, as well as the Leptocephali, are true pelagic organisms. The Leptocephali likewise belong to the upper layers (high up at night, lower down in the day time), but there is the difference that during their prolonged existence they spread over greater distances and are also found over shallower waters than the pre-Leptocephali.

The first stages in the transformation also proceed pelagically, but thereafter the different species behave differently. Whilst some species during transformation go deeper down in the sea (*e.g.* Synaphobranchus), others (*e.g.* Conger and the common eel) undergo most of their metamorphosis in the upper layers. In their later life the former live in great depths, the latter in shallower water near the coast, and even in fresh water. When the time for reproduction arrives, all descend again into the oceanic depths whence they came, spawn but once, so far as we know, and never return.

JOHS. SCHMIDT.

Copenhagen, February 8.

[1] Four species of Leptocephali, one of Tilurus, and first and foremost the two Conger species (*C. vulgaris* and *C. mystax*) form the basis of this summary.

REPORT OF THE CARNEGIE FOUNDATION.

THE fifth annual report of the president of the Carnegie Foundation for the Advancement of Teaching covers the year ending September 30, 1910. The report is divided into two parts. Part i. pertains to the current business of the year; part ii. is a discussion of the relation of the college and the secondary school.

The report shows that the trustees had in hand at the end of the year funds amounting to 2,222,811*l.*, consisting of the original gift of 2,000,000*l.* par value of 5 per cent. bonds and 200,000*l.* accumulated surplus. The income for the year was 108,776*l.* During the year sixty-four retiring allowances were granted, of which forty-six were in accepted institutions and eighteen in institutions not on the accepted list.

In the first part of the report the president of the foundation follows up the bulletin on medical education by a paper on the relation of the university to the medical school, in which he directs attention to the responsibility attaching to any college or university which undertakes medical education.

The second part of the report is a careful attempt to state the existing causes of friction between the secondary school and the college, and the loss of educational efficiency in the present methods of bringing pupils from the school to the college. The complaint of the college against the secondary school, and the complaint of the secondary school against the college, are set forth.

An extremely interesting part of the report is a statement of the observations of Oxford tutors upon the preparation of the Rhodes scholars. The strong points in the American youth's preparation are readily seen by these trained teachers, and the weaknesses which they find point directly to the superficiality and diffusion of the work done in the American secondary school and college.

The president of the foundation urges that this whole question be approached by secondary-school men and college men in a spirit of cooperation. Neither the certificate method of admission nor the piecemeal examination method have in his opinion solved the problem. He urges that the college must find a solution which will test better than the certificate or the piecemeal examination the fundamental qualities of the student, and which will at the same time leave to the high school a larger measure of freedom. He recommends a combination of certificate and examinations, the latter of a simple and elementary character, but calling for a high quality of performance, without which the candidate will not be admitted. For example, under this plan the boy who cannot write good idiomatic English would not be admitted to college at all, but would be sent back to the secondary school. The entrance requirements recently adopted at Harvard are quite in line with these recommendations. The president of the foundation urges a cooperation between the secondary school and the college, not as unrelated institutions, but as two parts of a common system of education. He argues that the interest of the great mass of high-school students must not be sacrificed to the interest of the minority who are looking toward college. He insists on a larger measure of freedom for the secondary school, but, on the other hand, he argues that the interest of the boy who goes to college and of the boy who goes from the high school into business are alike conserved by learning a few things well, not by learning many things superficially. The boy who has obtained such intellectual discipline is a fit candidate for college, whether he has studied one set of subjects or another; without this intellectual discipline he is unfit alike for college or business. It is therefore, in the opinion of the president of the foundation, the plain duty of the college, at the present stage of American educational development, to articulate intimately with the four-year high school and to leave to the secondary school the largest freedom so that it may educate boys, not coach them, but at the same time to require of the candidates for admission tests which rest upon high performance in the elementary studies and which mean mastery of the fundamentals. In such a programme lies the hope of scholarly betterment and of civic efficiency both for college and high school.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

BIRMINGHAM.—The legacy of 20,000*l.* bequeathed by the late Mr. John Feeney has been applied to the endowment of the chair of metallurgy, which is henceforth to be known as the "Feeney Chair of Metallurgy."

The Huxley lecture for this year is to be delivered by Prof. Henri Bergson, lecturer in philosophy at the University of Paris.

In addressing the Court of Governors at the annual meeting, the Vice-Chancellor referred with satisfaction to the recent grant of an additional halfpenny rate by the City Council, "which they all acknowledged had been generous." The principal (Sir Oliver Lodge) in his speech, which followed that of the Vice-Chancellor, defended the University against the charge of extravagance which had been brought against it in some quarters. He pointed out that "in this country we are behind in educational matters, and have been excessively economical when we ought to have been lavish in outlay." He stated that certain departments are better equipped in other modern universities in England, and that it must not be assumed that what Birmingham had done was "to be regarded as something out of the way and extraordinary." He also expressed the opinion that "it was highly important that universities, whatever aid they received, should not become appendages of State departments of the Civil Service. All our modern universities were experiments started by the nation in higher education, and no Government office or official was competent to control the highest education in the country. The only reasonable way was to trust the institutions and the experts called